LED ARRANGEMENT

The invention is directed to an LED arrangement according to the preamble of patent claim 1 that, in particular, can be built into a lamp housing as can be employed, for example, in exterior lights of motor vehicles.

In the field of exterior and interior illumination of motor vehicles, light-emitting diodes (LEDs) are being increasingly used instead of conventional incandescent bulbs, particularly for tail lights and brake lights, since LEDs have a longer service life, a better efficiency in the conversion of electrical energy into radiation energy in the visible spectral range and, connected therewith, a lower heat emission and a lower space requirement overall.

EP 0 253 224 discloses a method for the manufacture of a light with light-emitting diodes. The light to be manufactured comprises a soft plastic film on whose upper side a copper lamination is applied and a plurality of light-emitting diodes are arranged. The plastic film has its side lying opposite the upper side glued onto a metallic carrier plate. The light is provided for employment in a motor vehicle, whereby the carrier plate can be implemented bent for adaptation to the shape of a motor vehicle.

Further, US 5,782,555 discloses a traffic signal light that comprises a plurality of LEDs as luminous members. The LEDs are secured on the surface of a printed circuit board that is provided with a both-sided metallization. A plurality of through holes via which the metallizations are connected to one another are formed in the printed circuit board. The printed circuit board is secured with an adhesive to a cooling member that is provided with an electrically insulating surface.

US 5,890,794 discloses another lighting unit on the basis of LEDs. Here, a plurality of radial LEDs is mounted on a printed circuit board, whereby the wire leads are conducted through the printed circuit board in a traditional way. In one illustrated embodiment, the printed circuit board is flexible and applied onto a cylindrical member. A coolant fluid is preferably employed for cooling.

A certain added outlay must be incurred first when constructing a light with LEDs since, due to the low luminance of an individual LED compared to an incandescent bulb, a plurality of LEDs shaped to form an array must be constructed.

For example, such an array can be mounted [sic] in surface mounting technology (SMT, surface mount technology) from a plurality of LEDs on a printed circuit board (PCB). An LED structure as described, for example, in the article "SIEMENS SMT-TOPLED für die Oberflächenmontage" by F. Möllmer and G. Waitl in the periodical Siemens Components 29 (1991), Number 4, page 147 in conjunction with Figure 1 is thereby employed. The form of the LED is extremely compact and allows the arrangement of a plurality of such LEDs in a row or matrix arrangement as warranted.

However, only approximately 5% of the electrical power is converted in the form of light within the housing of such an LED that, for example, emits yellow-colored or amber-colored light, whereas approximately 95% is converted in the form of heat. This heat is eliminated from the underside of the chip via the electrical terminal of the component. Dependent on the structure, the heat given the components of the assignee known by the names TOPLED or Power TOPLED is first conducted our of the housing onto the solder points on the printed circuit board by one or three existing cathode terminals. From the solder points, the heat at first propagates in the copper pads and then on the epoxy resin material in the plane of the printed circuit board. Subsequently, the heat is output large-area to the environment by thermal radiation and thermal convection. The thermal resistance is still relatively slight in the case of a single LED on FR4 circuit board material (for example, approximately 180 K/W given an LED of the type Power TOPLED®).

The situation is different, however, when many LEDs are arranged in close proximity on a circuit board. A smaller percentual area of the PCB is now available for each individual LED for the heat transmission to the environment. The thermal resistance from the PCB onto the environment is correspondingly higher. Given a components spacing of, for example, 6.5 mm, the thermal resistance rises to

up to 550 K/W when the LEDs are of the type Power TOPLED and the printed circuit board is of the type FR4.

Heat is emitted from all heat-generating components on the circuit board, i.e. from the dropping resistors, transistors, MOSFETs or drive ICs as well, that are located in the immediate proximity of the LEDs. The operating current must be reduced so that a destruction of the component does not occur as a consequence of the hear generation on the circuit board and the inadequate heat elimination. The luminous power of the LEDs, accordingly, cannot be fully exploited.

LED arrangements are utilized for the third brake light in the aforementioned field of motor vehicle lighting. This is a single-line array wherein the thermal problems are not yet so critical.

It is therefore an object of the present invention to improve an LED arrangement of the species initially cited such that the luminous power of the LEDs can be as optimally utilized as possible. In particular, an object of the present invention is to specify a surface-mounted LED arrangement that is distinguished by an improved heat elimination from the LEDs. In addition, an LED arrangement should be made available with which different spatial shapes of three-dimensional lamps can be realized in a simple way.

This object is achieved by an LED arrangement having the features of patent claim 1. Advantageous developments of the invention and preferred lighting devices having inventive LED arrangements are the subject matter of patent claims 2 through 14.

According to the invention, an LED arrangement with a printed circuit board and a plurality of LEDs -- surface-mounted LEDs are especially preferred -- is provided, whereby the printed circuit board has its side facing away from the LEDs applied on a cooling member and comprises a metallic layer with good thermal conductivity on this side that is electrically insulated from the LEDs by the printed circuit board. The invention is thus based on the perception that the heat elimination toward the back must be promoted, particularly given a surface-mounted LED arrangement having a high LED density.

The cooling member can, for example, be composed of copper or aluminum or of a cooling plate, and the printed circuit board is preferably secured on it with a thermally conductive paste, a thermally conductive adhesive, a thermally

conductive film or the like. It should enable an optimally good heat dissipation at its back side. To this end, for example, it can be painted black and/or comprise cooling ribs and/or a rough surface.

Further, the printed circuit board should be as thin as possible since the plastic material of which it is constructed usually conducts heat poorly. For example, the printed circuit board can be a flexible printed circuit board. The flexible printed circuit board is generally manufactured of a flexible plastic. For example, it can be composed of polyester or polyimide film. The employment of what are referred to as flex boards, which are notoriously known in the Prior Art, is especially preferred. These flex boards are generally multi-layer printed circuit boards that are uniformly constructed of a plurality of polyimide carrier films.

Further, the copper pads around the solder surfaces of LEDs applied with surface mounting technique (SMT) should be as large as possible in order to broaden the heat path through the printed circuit board material before the heat flows to the back side of the printed circuit board. Preferably, the principal face of the printed circuit board facing toward the cooling member is laminated with copper or some other metal in order to still enable thermal conduction transversely to other glue locations given cavities in the lamination. For example, the copper layer can be

can be adapted to the outside contour of the vehicle in a space-saving fashion. For example, the cooling member can be directly formed by a partial surface region of an automobile chassis (for example, the headlight or tail light region of the fenders) or a device housing or the like.

The exemplary embodiment of Figure 2B shows an axial crossection through a rotating light of a type that can, for example, be employed in emergency vehicles. Given to rotating light of Figure 2B, the flex board 1 provided with an array of LEDs 2 is laminated around a tubularly shaped, cylindrical, hollow cooling member 3. In this exemplary embodiment, the LEDs of the array proceeding parallel to the axis can be additionally combined to form lanes that are successively driven in a clockwise direction (see arrow), so that a rotating light is produced. At one point in time, one lane or a specific plurality of neighboring lanes can thereby be driven simultaneously. For bundling the emitted light, moreover, the LEDs 2 can be provided with lenses 5. This embodiment has the great advantage that practically all mechanical parts that have hitherto been needed for rotating lights of a conventional type are eliminated. As desired, the cylindrical cooling member 3 can also have a gas such as air or a liquid coolant flowing through it for further improvement of the heat elimination.

Figure 2C shows a perspective view of a three-dimensionally arced light dome. The light dome comprises a regular shape with an upper surface and four obliquely placed side surfaces, two respective side surfaces thereof being arranged axially symmetrically relative to one another. The cooling member itself cannot be seen in the illustration of Figure 2C since it is completely covered by the flex board. The flex board 1 comprises a plurality of sectors corresponding to the surfaces of the cooling member and wherein a plurality of LEDs 2 arranged in an array are respectively mounted. As wanted, the LEDs 2 can be provided with lenses for bundling the emitted light. Such a light dome can be utilized for all types of lighting purposes.